A PROGRAMMED SEQUENCE ON

# EXPONENTIAL NOTATION

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A Programmed Sequence on

# EXPONENTIAL NOTATION

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Work in science often requires very large or very small numbers such as 602,300,000,000,000,000,000,000. A convenient way to handle these is through exponential notation, which this booklet explains. There are five parts



## How to Use This Booklet

This coverage of exponential notation is designed to be undertaken by you on a self-instructional basis. Using a small sheet of paper or cardboard as a mask, you are to conceal the answers which are listed in the right hand columns of the booklet until you have actually written down your own response on a separate sheet of paper. Do not mark this booklet itself so others will be able to use it again.

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POWERS OF TEN

AND

EXPONENTIAL NOTATION

In science there is often a need to work with very large and very small numbers. From the distances of space to the distances in molecules, we are concerned with measurement.

This booklet is designed to show you a way of expressing and using very large and very small numbers. It is intended that this should be undertaken as self-instruction on your part should you need either a rapid review or an introduction to this topic. Using a small sheet of paper or cardboard as a mask, conceal the answers in the right hand margin until you have actually <u>written</u> down your own response on a separate sheet of paper. DO NOT MARK THIS BOOKLET.

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Let's start with some moderate sized numbers as examples. Just as 20 may be written as 2 x 10,

1 so may 40 be written as ________, 4 x 10

2 so, too, 70 may be written as ________. 7 x 10

We can also write 300 as 3 x 100

3 and 500 as ________ 5 x 100

4 and 800 as ________. 8 x 100

We can go even further; into the thousands.

5 6000 = 6 x ____. 1000

6 7000 = ____ x 1000 7

7 or 9000 = ____ x ____ 9 x 1000

8 80,000 = ____ x 10,000 8

---

9 Since 100 = 10 x 10, we see that we can factor 100 into 2 equal parts. Likewise, since 1000 = 10 x 10 x 10, we can factor 1000 into ____ equal parts. 3

We can more conveniently indicate these equal factors using exponents. For example,

$100 = 10 \times 10 = 10^2$

10 And, $1000 = 10 \times 10 \times 10 = 10^?$ $10^3$

So, in place of the 1000 in (6 x 1000) we could write

11 $6 \times 10^?$ $10^3$

Note that we now have 6000 = 6 x $10^3$. In a similar way, since 50,000 = 5 x 10,000, we could write

50,000 = 5 x $10^4$.

12 Note that there are _____ zeros in 50,000, and that 4

13 the exponent of 10 is also _____. 4

In 20,000,000 = 2 x $10^7$,

14 the exponent is _____. 7

15 The number of zeros in 20,000,000 is _____. 7

The relationship here seems to be that the value

16 of the __________ of 10 is the same as the number exponent

17 of _______ in the original numeral. zeros

---

Using this relationship, complete the following:

18 3,000,000 = 3 x $10^?$ $10^6$

Change the following numerals to this exponential form:

19 a) 300 3 x $10^2$

20 b) 80,000 8 x $10^4$

21 c) 100,000 1 x $10^5$

---

Let's drop back for a moment to some smaller numbers. If we can write

25 as 2.5 x 10,

and 39 as 3.9 x 10,

22 we can also write 45 as _____ x 10. 4.5

23 We can also write 87 as _____ x 10. 8.7

When we jump up into the hundreds we can use the same system.

350 can be written as 3.5 x 100

24 and 630 can be written as 6.3 x _____. 100

---

But, we know 100 can be written as $10^2$

25 so we now write 6.3 x 100 as _____ x $10^2$. 6.3

In a similar way, 5,600 can be written as

5.6 x 1000

26 or as _____ x $10^3$. 5.6

---

Let's look again at the last expression in the preceding box.

We have 5,600 = $5.6 \times 10^3$.
A B C

In changing 5,600 to 5.6, we moved the decimal
27 point _____ places. 3

If your last answer in the above box was correct, go on to the next box.

If you're puzzled as to where the decimal point is in the numeral 2758, continue on here.

28 When a numeral such as 2758 is written without a decimal point, where do we assume the decimal point to be?

a) In front of the 2.
b) Between the 7 and the 5.
c) After the 8 — After the 8.

So, 2758 = 2758.

29 Where is the decimal point understood to be in the numeral 142? — 142. (After the 2.)

If it is not indicated, the decimal point is assumed
30 to follow the _____ digit of a number. last

In changing 5,600 to $5.6 \times 10^3$ the decimal point was
31 moved _____ places. three

In changing 5600 to $5.6 \times 10^3$ we found that the decimal point was moved 3 places. It's important to notice that the exponent in this expression
32 is also _____. 3

As another example, take the following

$$73{,}400 = 7.34 \times 10^4.$$

We note that in changing 73,400 to 7.34 the decimal
33 was moved _______ places, and that the exponent used 4
34 is also _______. 4

We might even go so far as to state this as a rule of thumb, namely that the decimal point change equals
35 the _______ of 10. exponent

36 Try this rule in determining the exponent in the following expression:

$$3678 = 3.678 \times 10^?$$ — $10^3$

If your answer was correct, go to the next box.

If you are wondering how this last answer was obtained, or would like to have more practice, copy down the following, including the letters:

$$3678 = 3.678 \times 10^?$$
A B C

37 In the numeral 3678 (Part A), put in the decimal point. — 3678.

(If this last answer is puzzling to you, you may want to review Items 28 to 30.)

38 In changing 3678. in A to 3.678 in B, how many places would you move the decimal point? 3

Since you moved the decimal point 3 places, then the

39 exponent in part C would also be _______. 3

40 Now complete your problem: 3678 = $3.678 \times 10^?$ $10^3$

---

41 Copy and complete the following: 789 = $7.89 \times 10^?$ $10^2$

If your answer was correct, go to the next box.

If you are not sure just how this result was obtained, copy down the problem given below, including the letters:

$$\underset{A}{789} = \underset{B}{7.89} \times \underset{C}{10^?}$$

In changing the numeral at A to the numeral at B you

42 would move the decimal point _______ places. 2

Therefore the exponent of 10 (at C) would also

43 be ________. 2

44 Now complete your problem: 789 = $7.89 \times 10^?$ $10^2$

---

45 Copy and complete the following:

16,000,000 = $1.6 \times 10^?$ $10^7$

If your answer was correct, jump to the next box.

If you want to go through this problem in more detail, copy down the following, including the letters:

$$\underset{A}{16{,}000{,}000} = \underset{B}{1.6} \times \underset{C}{10^?}$$

46 Locate the decimal point in part A. 16,000,000.

In changing the numeral at A to the numeral at B, you

47 would move the decimal point ______ places. 7

Therefore the exponent in part C would have a value

48 of _______. 7

49 Now complete your problem

16,000,000 = $1.6 \times 10^?$ 16,000,000

by inserting the proper exponent. = $1.6 \times 10^7$

---

Complete the following: 484,000 =

50 484,000 = 4.84 x _______ $4.84 \times 10^5$

Copy and complete the following: 363,000 =

51 363,000 = 3.63 __ _______ $3.63 \times 10^5$

In the last answer, note that the "x" stands for "times", and must be included.

52 Copy and complete: 148,000,000 = 1.48 __ _____ $1.48 \times 10^8$

53 Copy and complete: 14,500 = _____ __ ______ $1.45 \times 10^4$

---

In looking back over the answers that you have written you'll notice that they are in the following general form:

$$\underset{A}{2500} = \underset{B}{2.5} \times \underset{C}{10^3}$$

Notice particularly that in the part labeled B there

54 is always only ______ digit to the left of the decimal point. one

$$\underset{A}{2500} = \underset{B}{2.5} \times \underset{C}{10^3}$$

The "standard form" for exponential notation is represented by parts B and C in the above expression. There is only <u>one</u> <u>digit</u> to the left of the

55 ________ _______. decimal point

56 The following 3 numerals are all equal, but only one is in the standard form. Which one is it?

| A | B | C |
|---|---|---|
| $23.5 \times 10^3$ | $2.35 \times 10^4$ | $0.235 \times 10^5$ |

$2.35 \times 10^4$ B

We recognize this as the "standard form" because it

57 has only ____ digit to the left of the _______ ______. one, decimal point

---

58 Change 8500 to the standard form in exponential notation. $8500 = 8.5 \times 10^3$

If you got this answer correct, go to the next box.

If you'd like a little fuller explanation of this last problem, copy down the following exactly as shown.

$$\underset{A}{8500} = \underset{B}{\_\_\_\_}\ \_\_\ \underset{C}{\_\_\_\_\_\_}$$

59 Mark the decimal point in part A. $\underset{A}{8500.}$

60 Change the numeral of A so there is only one digit to the left of the decimal point, and copy it above B on your paper. $\underset{B}{8.5}$

Note that in B we've just dropped the extra zeros since they only serve to fix the decimal place in the original numeral.

You now have $\underset{A}{8500.} = \underset{B}{8.5}\ \_\_\ \underset{C}{\_\_\_\_\_\_}$

In changing the numeral from A to B, you moved the

61 decimal point ____ places. 3

Therefore, the 10 in part C will have an exponent

62 of _______. 3

63 Put in the 10 with this exponent in part C. $10^3$

Now you have: 8500. = 8.5 __ $10^3$
A B C

The only thing missing from a correct answer now is
64 the "_____" sign which goes in the blank space. "times"
(Put it in your answer if you haven't done so already.)

Now your expression is complete and looks like this:
8500. = 8.5 x $10^3$

---

65 Change the distance from the earth to the sun, 93,000,000 miles, to the standard exponential form. 9.3 x $10^7$ miles.

---

66 One estimate places the world population at 2,870,000,000 people. Express this in exponential notation. 2.87 x $10^9$ people.

---

66 Change the following number to exponential notation:
602,000,000,000,000,000,000,000 6.02 x $10^{23}$

---

We may want to change an exponential notation back to its usual numerical form. Suppose, for example, we want to change 2.5 x $10^3$ back to its usual
67 numerical form. Here the exponent is _______. 3

This means that the decimal point will also be
68 shifted by _____ places. three

Thus, 2.5 x $10^3$ = 2500

From this example we can see that the shift in the
69 decimal point is determined by the _______ of the 10. exponent (power)

---

70 Change 1.49 x $10^4$ to its usual numerical form. 14,900

If you got this right, and you think you have the idea of this change, go to the next box. For a detailed coverage of this problem continue on here.

71 In 1.49 x $10^4$ = ___?___, what is the exponent of 10? 4

72 Therefore, how many places will we move the decimal point? 4 places

73 When you move the decimal point 4 places in the numeral 1.49, what new numeral do you get? 14,900

In case your last answer was 0.000149, remember we have been dealing, thus far, in numbers which are
74 __________ (smaller, larger) than 1. larger

Now you can complete the problem,
75 1.49 x $10^4$ = _______ 14,900

| | | |
|---|---|---|
| 76 | Change $4.7 \times 10^5$ to its usual numerical form. | $4.7 \times 10^5$ = 470,000 |
| | If you made this conversion easily, move on to the next box. | |
| | For a detailed coverage of this conversion, recopy the problem: $4.7 \times 10^5 = \underline{\ \ ?\ \ }$ | |
| 77 | What is the value of the exponent in this expression? | 5 |
| 78 | Since the exponent is 5, when the 4.7 is converted to the usual numerical form, the decimal point will be shifted ________ places. | 5 |
| 79 | Make this shift in the decimal point of 4.7. | 470,000 |
| 80 | Insert this as your conversion in $4.7 \times 10^5$ = ______. | 470,000 |
| 81 | Change $1.84 \times 10^{13}$ to the usual numerical form. | 18,400,000,000,000 |
| 82 | Change $3 \times 10^3$ from its exponential form. | 3000 |
| 83 | Change $9.9 \times 10^7$ from its exponential form. | 99,000,000 |
| 84 | Thus far, all our work with exponential notation has been with numbers which have been ________ (larger, smaller) than one. | larger |
| 85 | It is also quite possible to use this same exponential notation to represent numbers which are ________ than one as well as numbers which are larger than one. | smaller |
| | Compare these two exponential forms: $\underset{A}{2.5 \times 10^3}$ $\underset{B}{2.5 \times 10^{-3}}$ | |
| 86 | A and B represent two different numbers. The only difference between them is that B has a ________ | negative |
| 87 | exponent, while A has a positive ________. | exponent |
| | We are comparing $\underset{A}{2.5 \times 10^3}$ and $\underset{B}{2.5 \times 10^{-3}}$ | |
| 88 | From our previous work we recognize that A represents a relatively ________ (large, small) number. | large |
| 89 | In contrast to A, B represents a relatively ________ (large, small) number. | small |
| 90 | We might then expect that since the positive exponent in A represents a relatively large number, the negative exponent in B represents a relatively ________ number. | small |

| | | |
|---|---|---|
| | Thus, small numbers -- that is, less than one in | |
| 91 | value -- will have a __________ (positive, negative) exponent in exponential notation. | negative |
| | All the manipulations we have been doing will still apply. We'll just have to note that numbers less | |
| 92 | than 1 will have a __________ exponent. | negative |
| | Thus a negative exponent is used in the exponential | |
| 93 | notation if the number is ________ than one. | less |

| | | |
|---|---|---|
| | Copy the following example, including the letters: | |
| | $\underset{A}{0.0018} = \underset{B}{1.8} \times \underset{C}{10^{?}}$ | |
| | In going from the numeral at A to that at B, the | |
| 94 | decimal point was moved __________ places. | 3 |
| | Since the numeral at A is less than one, the exponent | |
| 95 | in C will be _____ (+3, 3, -3). | -3 |
| 96 | Now complete the problem $0.0018 = 1.8 \times 10^{?}$ | $10^{-3}$ |
| | One thing you ought to note in this example, | |
| | $\underset{A}{0.0018} = \underset{B}{1.8} \times \underset{C}{10^{-3}}$ | |
| 97 | is that the numeral in B still has only _____ digit | one |
| 98 | to the left of the __________ __________. | decimal point |
| | So it is in our standard form. | |

| | | |
|---|---|---|
| 99 | Copy and complete the following: $0.036 = 3.6 \times 10^{?}$ | $10^{-2}$ |
| | If you were correct and feel you have this operation down pretty well, go on to the next box. | |
| | For a more detailed coverage, copy down the following, including the letters: | |
| | $\underset{A}{0.036} = \underset{B}{3.6} \times \underset{C}{10^{?}}$ | |
| | A is our original numeral. We are going to change it to the standard form at B by moving the decimal point | |
| 100 | _____ places. | 2 |
| 101 | Our original numeral at A is __________ (greater, less) than one. | less |
| 102 | This means our exponent in C will be ______ (+, -). | - (negative) |
| | So, our exponent will be 2 (same as the decimal point shift) and negative (the numeral is less than one). | |
| 103 | Put this exponent in your problem. | $0.036 = 3.6 \times 10^{-2}$ |

| | | |
|---|---|---|
| 104 | Copy and complete the following: 0.0007 = 7 __ ______ | $0.0007 = 7 \times 10^{-4}$ |

| | | |
|---|---|---|
| | If you understand this last problem, jump to the next box.<br><br>If you'd like a more detailed coverage, copy down this problem, including the letters:<br><br>$\underset{A}{0.0007} = \underset{B}{7}\ \_\_\ \underset{C}{\_\_\_\_\_\_}$ | |
| 105 | Right after the 7, put in the symbol for "times". | 0.0007 = 7 x ______ |
| 106 | Next, insert the base 10 at C.<br><br>(These two parts are not really equal, yet, but we'll leave the "equals" sign in, anyhow.) | This gives us 0.0007 = 7 x 10 |
| 107 | Now we need to determine the proper exponent for part C. The numeral in A is ________ than one. | less |
| 108 | This tells us that the exponent of the 10 will be __________ (positive, negative). | negative |
| 109 | In changing the numeral from A to B, the decimal point was shifted ________ places. | 4 |
| 110 | So, we know that the exponent of ten will be ________ (+4, -4). | -4 |
| 111 | Now, complete this problem by inserting the correct exponent. | 0.0007 = $7 \times 10^{-4}$ |
| 112 | Copy the following and change it to exponential notation:<br><br>0.00000000013 = ______ x ______.<br><br>If you were able to do this easily, hop on to the next box.<br><br>To go through this solution more deliberately, copy down the following, including the letters:<br><br>$\underset{A}{0.00000000013} = \underset{B}{\_\_\_\_\_\_} \times \underset{C}{\_\_\_\_\_\_}$ | 0.00000000013 = $1.3 \times 10^{-10}$ |
| 113 | In the standard exponential form, what will the numeral at B be?<br><br>Insert this value in your problem, and include the times sign and the base 10.<br><br>Now your problem looks like this.<br><br>0.00000000013 = 1.3 x 10 | 1.3 |
| 114 | What is still missing from this example? | The exponent of 10. |
| 115 | Will this exponent be positive or negative? | negative (A is less than one.) |

| | | |
|---|---|---|
| 116 | How many places was the decimal point moved in changing the numeral at A to that at B? | 10 |
| 117 | So, the exponent of the base 10 will be ________. | -10 |
| | (You did use the correct sign, didn't you?) | |
| 118 | If so, put this exponent in your problem to complete it. | 0.00000000013 $= 1.3 \times 10^{-10}$ |
| 119 | Change the following to exponential notation: | |
| | 0.0000178 | $1.78 \times 10^{-5}$ |
| | If you've got the idea, jump ahead to the next box. | |
| | For a closer look at how we got this answer, copy down the following: | |
| | 0.0000178 = ________ __ ________ <br> A B C | |
| 120 | Insert the proper numeral at B and put in the times sign. | 0.0000178 = 1.78 x ____ |
| 121 | What base will you put at C? | 10 |
| | Put the base 10 at C. | |
| | This gives you the following: | |
| | 0.0000178 = 1.78 x 10 <br> A B C | |
| 122 | What is still missing from this expression? | The exponent of 10. |
| 123 | What should the exponent be? | -5 |
| | If you see where this last answer came from, insert it in your problem and go to Item No. 128. | |
| | To see where this answer came from, count the number of places the decimal point was shifted in changing the numeral at A to the numeral at B. If your answer sheet is not clear, look back to Item No.121. The number of places the decimal point was shifted | |
| 124 | was ________. | 5 |
| 125 | Is A greater than one or less than one? | less than one |
| 126 | Therefore the exponent will be ________ (positive, negative). | negative |
| 127 | Thus, our exponent will be ________. | -5 |
| 128 | Insert this exponent in your expression to complete this problem. | 0.0000178 = $1.78 \times 10^{-5}$ |
| 129 | Change 0.015 to exponential form. | $1.5 \times 10^{-2}$ |
| 130 | Change 0.1 to exponential notation. | $1 \times 10^{-1}$ |

The reverse of this operation is naturally possible. In doing this, it necessary to note the sign of the exponent of 10 to determine if the numeral will be

131 smaller than one or ______ than one. — larger

Suppose we were to change $2.7 \times 10^{-7}$ to the usual numerical form.

132 Will the numeral be smaller or larger than one? — smaller than one

133 How did you know this? — The exponent is negative.

134 In changing $2.7 \times 10^{-7}$ to its usual numerical form, how many places will the decimal point be moved? — 7 places

135 How did you know this? — From the value of the exponent.

When the decimal point of 2.7 is moved 7 places, two different numerals could result:

| | | |
|---|---|---|
| 0.00000027 | or, | 27,000,000 |
| A | | B |

136 Which of these is correct for $2.7 \times 10^{-7}$? — 0.00000027

137 We know the numeral must be ______ than one since than one since the exponent is negative. — less

---

138 Change $3.4 \times 10^{-3}$ to the usual numerical form. — 0.0034

If this was O.K., go to the next box.

For a more detailed explanation, copy the following:

$$\underset{B}{3.4} \times \underset{C}{10^{-3}} = \underset{A}{\_\_\_\_\_\_}$$

139 What is the exponent of 10? — -3

Therefore the decimal point of 3.4 (B) will be moved

140 ______ places. — 3

The numeral which results from this decimal point

141 shift should be ______ (less, greater) than one. — less

(The exponent was negative, wasn't it?)

142 What will be the numeral for part A when the decimal point is shifted 3 places to give a numeral less than one? — 0.0034

---

143 Change $9.9 \times 10^{-9}$ from its exponential notation. — 0.0000000099

You may want to practice with the problems of Exercises 1 and 2, page 116 of your CHEM Study Laboratory Manual.

## SHIFTING DECIMAL PLACES
## IN EXPONENTIAL NOTATION

It is sometimes necessary to shift the decimal point in our exponential notation while performing some of the arithmetical operations with powers of ten.

1 We are now used to the exponential notation which is used to represent numbers. For instance, $3.45 \times 10^6$ is in the proper form for exponential notation because it has a decimal numeral with ____ digit to the left of the decimal point and is multiplied by a power of ____. — 1; 10

2 Sometimes it is necessary to change this standard form of exponential notation to get either a different decimal numeral or a different power of ____. — 10

---

However, no matter how we change the decimal numeral and the power of ten, we must not change the value of the expression.

3 What is the usual decimal form of $1.5 \times 10^3$? — 1500

In exponential notation we express this number as

$$1500 = 1.5 \times 10^3.$$

4 If we want to change the exponential form of this number, we could change the decimal numeral part so long as we also changed the power of ____ so that the new expression would still have the same value. — 10

---

Preliminary to doing this, though, we need to be able to compare numbers correctly.

5 Which represents the larger number, $2.4 \times 10^7$ or $1.5 \times 10^7$? — $2.4 \times 10^7$ is larger.

6 Which is larger, $10^5$ or $10^8$? — $10^8$ is larger.

7 Which is larger, $1.7 \times 10^3$ or $1.7 \times 10^4$? — $1.7 \times 10^4$ is larger.

8 Which is larger, $6.7 \times 10^3$ or $3.4 \times 10^4$? — $3.4 \times 10^4$ is larger. (Note the exponents.)

If you are in doubt as to which of two numbers shown in exponential notation is larger, you can always go back to the decimal form of the numbers and then compare them.

| | | |
|---|---|---|
| 9 | Suppose you came across a number written as $354.5 \times 10^6$ and you wanted to change it to the standard exponential form. This means the decimal numeral part should have only _____ digit to the left of the decimal point. | 1 |
| 10 | This means you will want to change 354.5 to ______. | 3.545 |
| 11 | In changing 354.5 to 3.545, you moved the decimal point _____ (how many) places. | two |
| 12 | Since you moved the decimal point two places, you will also have to change the exponent by _____. | two |
| | The exponent has to be changed by 2, but should it be 2 more, or 2 less. This is what we have to decide. Our problem is to change $354.5 \times 10^6$ to $3.545 \times 10^?$. | |
| 13 | The value of the expression must not be changed. So, since we have made the decimal part of the expression smaller, we must counteract this by making the power of ten part __________ (larger, smaller). | larger |
| 14 | To make the $10^6$ larger, shall we add or subtract the change of 2 in the exponent? | We should add 2. |
| 15 | Now complete this change of $354.5 \times 10^6$ to $3.545 \times 10^?$. | $3.545 \times 10^8$ |
| 16 | If you were to change $1678.9 \times 10^5$ to the proper form of exponential notation, how would you rewrite the decimal numeral part? | Change 1678.9 to 1.6789. |
| 17 | In making this change, how many places did you shift the decimal point? | three places. |
| 18 | This means we will also have to change the exponent by________. | 3 |
| | We are changing $1678.9 \times 10^5$ to $1.6789 \times 10^?$. | |
| 19 | Has the decimal numeral part of the expression (which is underlined) been made smaller, or larger? | smaller |
| 20 | This means, then, that to keep the same value, the exponent of the 10 will have to be _____ (smaller, larger). | larger |
| 21 | Since the decimal point was moved three places, the exponent will be increased by _____. | 3 |
| 22 | Now finish changing $1678.9 \times 10^5$ to $1.6789 \times 10^?$ by putting in the proper exponent. | $1678.9 \times 10^5$ is changed to $1.6789 \times 10^8$. |
| 23 | Complete the following: Change $23.45 \times 10^4$ to $2.345 \times 10^?$ | $2.345 \times 10^5$ |
| 24 | Change $13579.5 \times 10^9$ to $1.35795 \times 10^?$ | $1.35795 \times 10^{13}$ |
| 25 | Change $246.8 \times 10^4$ to our standard form for exponential notation. | $2.468 \times 10^6$ |
| 26 | Change $9753.1 \times 10^2$ to the standard form of exponential notation. | $9.7531 \times 10^5$ |

It may be necessary to go in the other direction in changing the decimal numeral to our standard exponential form. For instance, suppose our expression is <u>0.0023</u> x $10^5$ and we want to put it in our standard form.

27 First change the decimal numeral part (which is underlined) into the proper form.

Now we have 0.0023 x $10^5$ changed to 2.3 x $10^?$

Change 0.0023 to <u>2.3</u>.

28 How many places was the decimal point moved in making this change?

Decimal point was moved <u>three</u> places.

29 In changing 0.0023 x $10^5$ to <u>2.3</u> x $10^?$ has the decimal numeral (which is underlined) increased or decreased?

The decimal numeral (which is underlined) <u>increased</u>.

30 To balance or counteract this increase in the size of the decimal numeral the exponent of the power of ten part will have to be __________(increased, decreased).

decreased.

31 Since the decimal point was shifted 3 places the exponent will be decreased by _____ (how much).

3

So, the exponent of the ten will be decreased by 3.

32 Now complete this change: 0.0023 x $10^5$ is changed to 2.3 x $10^?$

0.0023 x $10^5$ is changed to <u>2.3 x $10^2$</u>.

We always apply the same principle -- if the decimal numeral part is changed, then the exponent must be changed in the opposite way so that the expression continues to represent the same value or quantity.

33 Try this one: Change 0.00067 x $10^9$ to the proper form of exponential notation:______________

6.7 x $10^5$

34 Change 0.45 x $10^2$ to the proper form in exponential notation____________or____________.

4.5 x $10^1$ or 4.5 x 10

Sometimes it may be necessary to alter our standard form of exponential notation. Thus, we must be able to change our decimal numerals or exponents any way we see fit.

For instance, let's make the following change:

Change 8.34 x $10^5$ to _______ x $10^7$

35 What three digits, regardless of the decimal point, will go into the blank space?

8, 3, 4 are the digits.

36 We may shift the decimal point, but we never change the ___________of the decimal numeral.

digits

Remember, we are changing 8.34 x $10^5$ to ______ x $10^7$.

37 What is the change in the exponent?

2

38 Does the exponent increase or decrease?

increases

39 The exponent increases by 2. To counteract this, the decimal numeral 8.34 must _________ (increase, decrease).

decrease

40 Thus the decimal point must be shifted two places to give a___________(larger, smaller) decimal numeral.

smaller

41 To get this smaller decimal numeral by shifting the decimal point two places we will change 8.34 to ________. 0.0834

42 Now, complete this change: $8.34 \times 10^5$ changes to ____$\times 10^7$. 0.0834

43 If the exponent increases in value, the decimal numeral part must then ________(increase, decrease) in order that the whole expression may not change its value. decrease

44 Change $6.98 \times 10^7$ to ______ $\times 10^8$. 0.698

45 Change $5.67 \times 10^{11}$ to _____ $\times 10^{10}$. 56.7

46 Now let's shift from very large numbers to very small numbers. When we are dealing with very small numbers (in which the exponents are negative) we still apply the same method: An increase in the decimal numeral must be accompanied by a decrease in the exponent. Or, turning this statement around, a decrease in the decimal numeral calls for an _________ in the exponent. increase

47 There is one tricky thing here, however. We are dealing with negative exponents when the number is _____(more, less) than one. less

This means we will be comparing negative exponents.

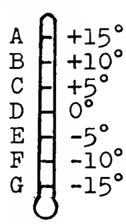
48 Which is greater, -1 or -2? -1

49 Which is smaller, -5 or -8? -8

If you got both of these last two answers correct and you feel you know how to compare negative numbers, go to Item No. 60.

If you missed either one of these last two items, you'll want to continue in this box.

On your paper, draw a rough copy of the diagram of a thermometer similar to the one shown below.




50 Which reading on the thermometer would indicate a higher (hotter) temperature, A or D? A

51 Which would be a higher temperature, a reading at A, +15°, or a reading at G of -15°? A at +15°

52 Which indicates a higher (larger) temperature, C at +5° or E at -5? C at +5°

53 Which is larger (higher temperature), E at -5 or F at -10? E at -5

54 Looking at your diagram, which is larger, -15 or -5 ? -5 is larger (higher)

55 Which is larger, -5 or -10 ? -5

56 Which is smaller, -15 or -10 ? -15

57 Which is larger, -8 or -6 ? -6

| | | |
|---|---|---|
| 58 | Pick out the smallest number: -10, -8, -15, -4 | -15 |
| 59 | Pick out the largest number: -2, -20, -200 | -2 |
| 60 | Which is larger, $10^{-8}$ or $10^{-9}$? | $10^{-8}$ |

| | | |
|---|---|---|
| | Now, let's try the following: Change $1.45 \times 10^{-5}$ to _____ $\times 10^{-6}$ | |
| 61 | By how much has the exponent changed? | It has changed by 1. |
| 62 | If the exponent was changed by 1, then the decimal point will be shifted ______ place. | one |
| 63 | We are changing $1.45 \times 10^{-5}$ to ____ $\times 10^{-6}$. Which is smaller, $10^{-5}$ or $10^{-6}$? | $10^{-6}$ |
| 64 | Since the new power of ten is smaller, the new decimal numeral must be _______(smaller, larger) to keep the value the same. | larger |
| 65 | In changing $1.45 \times 10^{-5}$ to _____ $\times 10^{-6}$, we have decided that the decimal point will be shifted one place and that the decimal numeral will be larger. What will the new decimal be: $\underline{14.5} \times 10^{-6}$ or $\underline{0.145} \times 10^{-6}$? | $\underline{14.5} \times 10^{-6}$ |

| | | |
|---|---|---|
| 66 | Now complete the following: $1.45 \times 10^{-5}$ = ______ $\times 10^{-6}$ | 14.5 |

| | | |
|---|---|---|
| 67 | See if you can fill in the blank with the proper decimal numeral. $6.84 \times 10^{-11}$ = ______ $\times 10^{-10}$ | 0.684 |
| 68 | In this problem, the value of the exponent increased, therefore the value of the decimal numeral had to ______. | decrease |

| | | |
|---|---|---|
| 69 | Try this change: $789 \times 10^{-7} = 7.89 \times 10^{?}$ | $7.89 \times 10^{-5}$ |
| | The decimal point was moved ___ places, giving us a smaller decimal numeral, so the exponent had to be increased | 2 |
| 70 | by ____. | 2 |

| | | |
|---|---|---|
| | Let's try one for a number greater than one, now --- | |
| 71 | $789 \times 10^{7} = 7.89 \times \underline{10^{?}}$ | $10^{9}$ |
| | The decimal point was moved two places giving us a | |
| 72 | _________(smaller, larger) decimal numeral, so the exponent had to be ___________(increased, decreased) by 2. | smaller increased |

You may want to practice on the additional problems given in Exercise 3, page 116 of your CHEM Study Laboratory Manual.

## MULTIPLICATION AND DIVISION WITH POWERS OF TEN

The multiplication of powers of ten is relatively simple. Since the powers of ten are actually exponents of the base ten, the rules for operations with exponents which you may have developed in a more formal manner in mathematics will apply here.

---

In multiplying expressions which have the same base (in exponential notation our base is always ten) we need only add the exponents to get the exponent of the product.

For example: $10^3 \times 10^2 = 10^{(3+2)} = 10^5$

1 Follow this example in doing the following multiplication:

$10^4 \times 10^2 = \underline{10^{(\_+\_)}} = \_\_\_$ $10^6$

2 $10^5 \times 10^8$ equals ______ $10^{13}$

3 $10^{\ 4} \times 10^{\ 3}$ = ______ $10^{\ 7}$

4 $10^2 \times 10^5$ = ______ $10^7$

---

The same rule applies even though the exponents may be negative. For example:

$$10^{-2} \times 10^{-3} = 10^{-5}$$

5 Complete the following:

$10^{-4} \times 10^{-2} =$ $10^{-6}$

6 $10^{-10} \times 10^{-13} =$ $10^{-23}$

7 $10^{-1} \times 10^{-2} =$ $10^{-3}$

8 Here, when we add negative exponents, the exponent of our result is also __________. negative

---

Now suppose we are working with both positive and negative exponents. Again, the same rule of algebraic addition of the exponents will apply.

$$10^5 \times 10^{-2} = 10^3$$

9 $10^7 \times 10^{-3} =$ $10^4$

10 $10^{-4} \times 10^9 =$ $10^5$

11 $10^{-15} \times 10^{20} =$ $10^5$

12 Here we can see that if the positive exponent has a larger numeral, then the exponent of the result will also be __________. positive

13 It will also be true that if the negative exponent has a larger numeral, then the exponent of the result will also be __________. negative

For example: $10^{-15} \times 10^{5} = 10^{-10}$

14 $10^{-8} \times 10^{6} =$ $10^{-2}$

15 $10^{-7} \times 10^{3} =$ $10^{-4}$

16 $10^{26} \times 10^{-28} =$ $10^{-2}$

In summary of these last four boxes, to add the exponents algebraically when they have different signs we disregard the signs shown, find the difference between the numerals and then put the sign of the larger original exponent in our result. If the exponents have the same sign, just add them.
Here are some samples to practice on:

17 $10^{12} \times 10^{5} =$ $10^{17}$

18 $10^{-12} \times 10^{5} =$ $10^{-7}$

19 $10^{-12} \times 10^{-5} =$ $10^{-17}$

20 $10^{12} \times 10^{-5} =$ $10^{7}$

In multiplying two expressions in exponential notation, the power of ten parts are multiplied together by adding the exponents (as we have already practiced) and the decimal numeral parts are multiplied together to get the decimal numeral part of the answer.

For example: $2 \times 10^{3}$ times $3 \times 10^{4}$ is the same as

$(2 \times 3)$ times $(10^{3} \times 10^{4})$ or $6 \times 10^{7}$

21 Multiply: $4 \times 10^{3}$ times $2 \times 10^{4}$ which is the same as

$(4 \times 2)$ times $(10^{3} \times 10^{4})$, or

_______ x _______ $8 \times 10^{7}$

22 Multiply $3 \times 10^{2}$ times $2 \times 10^{7}$ $6 \times 10^{9}$

23 Multiply $2.5 \times 10^{3}$ by $5 \times 10^{4}$ $12.5 \times 10^{7}$

However, this answer, while it is correct, is not in our "standard form" for exponential notation.

24 Change $12.5 \times 10^{7}$ to the approved form. $1.25 \times 10^{8}$

If you had trouble changing this answer to the "standard" form, refer to the earlier section on "Shifting Decimal Places."

25 Multiply $3.5 \times 10^{-7}$ by $7 \times 10^{-3}$ $24.5 \times 10^{-10}$

26 Changing this to our usual form of exponential notation, we get __________. $2.45 \times 10^{-9}$

Dividing by powers of ten is just as simple as multiplication. Here the rule of exponents also applies. If the bases are the same (as they always are in powers of ten), the exponent of the divisor (which you are dividing by) is <u>subtracted</u> from the exponent of the dividend (which you are dividing into).

For example: $\dfrac{10^5}{10^3} = 10^{(5-3)} = 10^2$

27 Using this same form do the following division:

$\dfrac{10^8}{10^2} = 10^{(\_\_\_\_)} = 10^{\_\_\_\_}$

$\dfrac{10^8}{10^2} =$ $10^{(8-2)} =$ $10^6$

---

28 Divide $10^{18}$ by $10^{11}$

$\dfrac{10^{18}}{10^{11}} = 10^7$

---

29 Complete: $\dfrac{10^{27}}{10^{25}} = \_\_\_\_\_$

$\dfrac{10^{27}}{10^{25}} =$ $10^{(27-25)} =$ $10^2$

---

30 $\dfrac{10^8}{10^{12}} = \_\_\_\_\_$

$\dfrac{10^8}{10^{12}} =$ $10^{(8-12)} =$ $10^{-4}$

---

31 $\dfrac{10^{-4}}{10^2} = \_\_\_\_\_$

$\dfrac{10^{-4}}{10^2} =$ $10^{(-4-2)} =$ $10^{-6}$

---

32 $\dfrac{10^{-6}}{10^{-4}} = \_\_\_\_$

$\dfrac{10^{-6}}{10^{-4}} =$ $10^{(-6+4)} =$ $10^{-2}$

If you answered these last 3 items correctly, and you understand how to subtract signed numerals skip the next box.

If you missed these last items, or feel you'd like to have a more detailed coverage of the subtraction of signed numerals, go on to the next box.

---

The algebraic subtraction rule is a simple one. Perhaps you remember from your work in mathematics that you merely reverse the sign of the numeral you are subtracting and go ahead and add.

For example: From 5 subtract 8

Change the sign of 8 from positive to negative, and add algebraically, giving us

5 plus -8 = -3

33 Subtract 6 from 4

(4) + (-6) = -2

34 If we are subtracting a negative number, we merely change its sign from negative to _______ and then add algebraically.

positive

For example: From 10 subtract -2

Here we would change the sign of the ______ (since we are subtracting it) and add algebraically, giving us 10 + 2 = _____.

-2

+12 or 12

Let's try a new one

35 Subtract -6 from 10

Here we will change the sign of the ______(-6, 10)

-6

36 Our answer will be _______

(10+6 = 16)

37 From -8 subtract -6

-2 (change the -6 to +6 and add)

38 Remember, in division of powers of ten, we will ________ (add, subtract) the exponent of the divisor.

subtract

39 Divide $\frac{10^6}{10^4}$ = ______

$\frac{10^6}{10^4} = 10^2$

40 $\frac{10^{-4}}{10^2}$ = _____

$10^{-6}$ (change +2 to -2 and add algebraically)

41 Try this one: $\frac{10^6}{10^{-2}}$ = ______

$10^8$ (change the sign of the -2 to 2, and add algebraically)

42 $\frac{10^{-2}}{10^{-5}}$ =

$10^3$ (change the sign of the -5 to 5 and add algebraically)

43 $\frac{10^{-9}}{10^{-4}}$ =

$10^{-5}$

Thus far, we have been concerned with only the power of ten part of our exponential notation. As we found in multiplication, the decimal numeral parts of the exponential notation format are divided and this quotient is combined with the power of ten part as shown below:

$$\frac{6.3 \times 10^5}{3 \times 10^2} = \frac{6.3}{3} \times \frac{10^5}{10^2} = 2.1 \times 10^3$$

44 Try this one, using this same form:

$$\frac{8.6 \times 10^7}{2 \times 10^5} = \_\_\_\_ \times \_\_\_\_ = \_\_\_\_ \times \_\_\_\_$$

$\frac{8.6}{2} \times \frac{10^7}{10^5} =$

$4.3 \times 10^2$

45 $\frac{1.44 \times 10^{-2}}{1.20 \times 10^{-6}} = ?$

$1.2 \times 10^4$

46 $\frac{5.25 \times 10^{-2}}{5 \times 10^{-7}} = ?$

$1.05 \times 10^5$

Sometimes it will be necessary to put our answer in the standard format of exponential notation.

47 For instance, if an answer comes out to be $0.018 \times 10^7$ we will want to change this to $1.8 \times 10^?$.

In all your problems, always put your answer in the standard form for exponential notation.

$0.018 \times 10^7$ is changed to $1.8 \times 10^5$

48 Try: $4.59 \times 10^7 \div 9 \times 10^{-4}$ equals ______

$5.1 \times 10^{10}$

49 $\frac{2.53 \times 10^{-3}}{1.1 \times 10^3} = ?$

$2.3 \times 10^{-6}$

50 $\frac{182 \times 10^5}{0.13 \times 10^6} = ?$

$1.4 \times 10^2$

You may want to practice on the additional exercise starting at the bottom of the left-hand column of page 117 in your CHEM Study Laboratory Manual.

EXTRACTION OF ROOTS
AND
RAISING TO A POWER

For the extraction of a root, such as a square root or a cube root, and so forth, of a power of ten, we shall use a simple rule which is based on a more formal development which you may have already gone through in your work in mathematics.

The rule: To extract the root of a power of ten, we merely divide the exponent of the power of ten by the root we wish to extract.

For example, to extract the square root you would divide the exponent of ten by 2. To extract the cube root, you would divide the exponent by 3.

1 To extract the fourth root, you would divide the exponent of the power by ten by ___. 4

To find the square root of $10^6$, we divide the exponent by 2. For example,

2 $\sqrt{10^6} =$ ___? $10^3$

3 $\sqrt{10^{10}} =$ $10^5$

4 $\sqrt{10^{-8}} =$ $10^{-4}$

5 To extract the cube root we would merely divide the exponent by the number ___ 3

6 $\sqrt[3]{10^6} =$ $10^2$

7 $\sqrt[3]{10^{-12}} =$ $10^{-4}$

If we have an expression in our exponential notation format, such as $9 \times 10^8$, to take the square root of this whole expression we take the square root of the numerical part, and multiply it by the square root of the power of ten.

For example, $\sqrt{4 \times 10^{10}} = \sqrt{4} \times \sqrt{10^{10}} = 2 \times 10^5$

Now try these:

8 $\sqrt{9 \times 10^{12}} = \sqrt{9} \times \sqrt{10^{12}} =$ ___________ $3 \times 10^6$

9 $\sqrt{36 \times 10^8} =$ ___________ $6 \times 10^4$

From your work in mathematics you will immediately recognize that we have omitted a very important part of the square root, namely its sign, which should be $\pm 3 \times 10^4$. This positive-negative sign is very important mathematically, but for our purposes the negative roots will not be important. We will be dealing with actual physical quantities in our work in chemistry. Negative weights or negative concentrations, for example, would have no application to our laboratory work. Hence, we can safely use only the positive root and ignore the

10 ____________ root. — negative

---

Maybe you've noticed that thus far we have carefully selected our examples so that the exponents are nicely, and evenly, divisible. But suppose you have the following problem: $\sqrt{1.6 \times 10^5} = ?$

In this case we could follow our rule and divide the exponent by 2. However, our result, while correct, would leave us with a fractional exponent which is awkward to work with. An easier system is to alter our expression so that it has an exponent which can be evenly divided by our root. In this case, shown above, we would want to change our exponent of ten from 5 to either 6

11 or ______. — 4 (or any even number)

Let's change it to 4 then.

12 $1.6 \times 10^5 =$ ____ $\times 10^4$ — 16

If this alteration is not clear to you, review the program on "Shifting the Decimal Place".

13 Now then, $\sqrt{1.6 \times 10^5} = \sqrt{16 \times 10^4}$ equals __________. — $4 \times 10^2$

---

If you were given this example, $\sqrt{14.4 \times 10^9}$, your first step would be to change this expression so that the

14 exponent would be ____. — even (divisible by 2)

Let's change the exponent to 8.

15 $14.4 \times 10^9 =$ ____ $\times 10^8$ — 144

Now finish this problem by taking the square root and putting your answer into the standard exponential form.

16 $\sqrt{14.4 \times 10^9} = \sqrt{144 \times 10^8} =$ ______________ — $12 \times 10^4 = 1.2 \times 10^5$

---

If the number is smaller than one, the exponents will be

17 __________ (positive, negative), but the same method is used. — negative

18 $\sqrt{9 \times 10^{-12}} =$ ________ — $3 \times 10^{-6}$

If you were given the following square root problem, $\sqrt{16.9 \times 10^{-11}}$, your first step would be to change this

19 expression so that the exponent would be__________ — even (or divisible by 2)

Let's change the exponent to -12:

20 $16.9 \times 10^{-11} =$ _____ $\times 10^{-12}$ — 169 (-12 is smaller than -11, so the decimal numeral must be larger)

Now, complete this square root problem:

21 $\sqrt{16.9 \times 10^{-11}} = \sqrt{169 \times 10^{-12}} =$ _________ — $13 \times 10^{-6}$, or $1.3 \times 10^{-5}$

Perhaps you noticed that all through this program we have selected decimal numerals which are perfect squares and hence the extraction of their square roots were easy. It is assumed that you will be able to extract the square root of any number through the use of logarithms, a slide rule, or "old fashioned arithmetic."

As you might suspect, the process of raising to a power is just the opposite of extracting a root. To raise to a power, you merely multiply an exponent by the power you are raising to. For example, suppose you were to raise $10^3$ to the second power or, $(10^3)^2$. Here you would multiply 3 times 2. Or, $(10^3)^2 = 10^6$.

22 What is $10^3$ raised to the 4th power? $(10^3)^4 =$ ______ $10^{12}$

23 $(10^9)^2 =$ ______ $10^{18}$

As before, if our number is expressed in exponential notation, we operate on the decimal numeral part separately from the powers of ten part. For example:

$(5 \times 10^3)^2 = 5^2 \times (10^3)^2 = 25 \times 10^6 = 2.5 \times 10^7$

Notice that we changed our answer into the regular exponential notation form.

24 In the same way, try $(4 \times 10^5)^2 = (\quad)^2 \times (\quad)^2 =$ ______ $(4)^2 \times (10^5)^2$ $16 \times 10^{10} =$ $1.6 \times 10^{11}$

This operation is exactly the same with negative exponents. When a negative exponent is raised to a

25 power, its sign does not change, so it is still ______ negative

26 $(1.50 \times 10^{-4})^2 =$ ______ $2.25 \times 10^{-8}$

27 $(8.10 \times 10^{-6})^2 =$ ______ $6.56 \times 10^{-11}$

28 $(3.00 \times 10^2)^3 =$ ______ $2.70 \times 10^7$

29 $\sqrt{4.41 \times 10^6} =$ ______ $2.10 \times 10^3$

30 $\sqrt{1.225 \times 10^5} =$ ______ $3.500 \times 10^2$

31 $\sqrt{3.6 \times 10^{-5}} =$ ______ $6.0 \times 10^{-3}$

32 $\sqrt{62.5 \times 10^{11}} =$ ______ $2.50 \times 10^6$

You may want to practice on the additional exercises at the bottom of the right-hand column of page 117 of your CHEM Study Laboratory Manual.

## ADDITION AND SUBTRACTION OF POWERS OF TEN

1 Suppose you were to perform the following addition:

$$ab + cb = ?$$

The term ab is made up of two factors, a and b. Likewise, the term cb is made up of two factors, namely _______ and _______. c and b

So, in the terms ab and cb we have four factors: a, b, c, b.

2 Which of these factors belongs to ab as well as cb? b

This means we can "factor out" b from the expression ab + cb to give us (a + c)b.

3 This is possible since ______ is a common factor of both ab and cb. b

---

Notice that this expression ab + cb is very similar to the problem of adding (or subtracting) quantities in exponential notation, such as

$$(2.5 \times \underline{10^6}) \quad + \quad (1.3 \times 10^6)$$

4 In each of these two expressions, the common factor is _______. $10^6$

Since $10^6$ is a common factor in $(2.5 \times 10^6)$ + $(1.3 \times 10^6)$ we could rewrite the addition of these two as

5 $(2.5 + 1.3) \times$ __?__ $10^6$

---

This tells us that two quantities in exponential notation may be easily added (or subtracted, for that matter) by merely adding (or subtracting) their decimal numeral parts, providing they each have the same exponent or power of ten.

6 In exponential notation, $\underset{B}{2.34} \times \underset{C}{10^5}$, the power of ten part is labeled with the letter ______. C

7 In $\underset{B}{2.34} \times \underset{C}{10^5}$ the decimal numeral part is labeled with the letter ______. B

8 Do these two expressions have the same power of ten?

$$2.34 \times 10^5 \qquad\qquad 5.67 \times 10^5$$

Yes

---

Our two expressions are $2.34 \times 10^5$ and $5.67 \times 10^5$

9 Since they have the same power of ten, these two expressions can be added together by merely adding their decimal numeral parts. That means we would add 2.34 to ______. 5.67

Our problem now looks like this:

$$(2.34 \times 10^5) + (5.67 \times 10^5) = (2.34 + 5.67) \times 10^5$$

10 When we add the decimal numeral parts together we get __?__ $\times 10^5$ 8.01

11 Notice that the power of ten part, which was a common factor, is ________ (unchanged, also changed). unchanged

| | | |
|---|---|---|
| 12 | Can these two be added together in their present form? $2.34 \times 10^6$ and $3.4 \times 10^7$ | No (Exponents unequal) |
| 13 | Can $4.32 \times 10^{-6}$ be added to $4.3 \times 10^{-6}$? | Yes (Exponents are equal) |
| 14 | Can these two be added together in their present form? $3.45 \times 10^8$ and $3.45 \times 10^4$ | No |
| 15 | Can $9.2 \times 10^7$ be added to $9.2 \times 10^5$ in their present form? | No (Exponents not equal) |
| 16 | Could $3.45 \times 10^8$ be subtracted from $7.4 \times 10^8$? | Yes |
| 17 | Can you subtract $3.45 \times 10^8$ from $7.4 \times 18^{10}$ in their present form? | No |
| | If two exponential expressions have the same exponent or power of ten, then their sum or difference will initially have this same power of ten. | |
| 18 | When $3.5 \times 10^3$ and $2.7 \times 10^3$ are added together, what will the power of ten be in the answer? | $10^3$ |
| | Since the power of ten does not change during the addition or subtraction all we have to be concerned with is the decimal numeral of the exponential notation. | |
| 19 | In the expression $2.34 \times 10^7$ the decimal numeral part is ________. | 2.34 |
| | The decimal numeral parts of the exponential expressions are added or subtracted as though they were by themselves. It is necessary, for instance, to line-up the decimal points before adding or subtracting. | |
| 20 | Add: $\begin{array}{r} 2.30 \times 10^5 \\ + \underline{4.56 \times 10^5} \end{array}$ | $6.86 \times 10^5$ |
| 21 | Subtract $2.34 \times 10^3$ from $5.67 \times 10^3$ | $3.33 \times 10^3$ |
| 22 | If the powers of ten or exponents of the two expressions which are being added or subtracted are not the same it is necessary to change the expressions until the tens have the ________ exponent. | same |
| | Suppose we needed to add these two expressions together: $2.46 \times 10^5$ and $3.57 \times 10^6$ | |
| 23 | Can they be added in their present form? | No. (They don't have the same powers of ten, or exponents) |
| 24 | Since we can't add them in their present form, we'll have to change one or the other so that the exponents will be ________. | the same |
| | Our two expressions are $\underset{A}{2.46 \times 10^5}$ and $\underset{B}{3.57 \times 10^6}$ | |
| 25 | To add these, we will want to either change A so that its exponent will be 6, or we will want to change B so that its exponent will be ____. | 5 (This will make the exponents equal |

Suppose we make each of the exponents equal to 5.

Our two expressions are $\underset{A}{2.46 \times 10^5}$ $\underset{B}{3.57 \times 10^6}$

A already has 5 for its exponent so we don't have to do anything to it.
We will have to change B so that its exponent will also be 5.

26 Complete this: B $3.57 \times 10^6$ equals ______ $\times 10^5$

$\underset{B}{3.57 \times 10^6} =$

$\underset{C}{\underline{35.7 \times 10^5}}$

(If you missed this last one, you may want to review the program on shifting decimal points.)

Note that both B and C have the same value - they are equal - but C now has the same exponent as A (A is $2.46 \times 10^5$), and therefore we can add A and C together.

$$\begin{array}{rl} 2.46 \times 10^5 & \text{(A)} \\ +\underline{35.7 \quad \times 10^5} & \text{(C)} \end{array}$$

27 The result is $\underline{\quad ? \quad}$ x $\underline{\quad ? \quad}$

$38.16 \times 10^5 =$
$38.2 \times 10^5$

However, this answer is not in our approved form of exponential notation.

28 Put this answer in its proper form of exponential notation.

$38.2 \times 10^5 =$
$\underline{\underline{3.82 \times 10^6}}$

Either of these last two expressions is correct. The second one is in the approved form.

29 Try this addition problem, and put your answer in the approved form:
$6.8 \times 10^4$ plus $5.79 \times 10^5$ (Change your powers until they have the same exponent--5, for instance--then add).

$\underline{6.47 \times 10^5}$
$(0.68 \times 10^5)$
$+ (5.79 \times 10^5)$
$= 6.47 \times 10^5$

30 Subtract $6.80 \times 10^{-11}$ from $6.88 \times 10^{-10}$ and put your answer in the approved form.

$\underline{6.20 \times 10^{-10}}$
$(6.88 \times 10^{-10})$
$- (0.68 \times 10^{-10})$
$= 6.20 \times 10^{-10}$

31 $(1.00 \times 10^{-5}) - (1 \times 10^{-7}) =$

$\underline{9.9 \times 10^{-6}}$
$(1.00 \times 10^{-5}) -$
$(.01 \times 10^{-5})$
$= 0.99 \times 10^{-5} =$
$9.9 \times 10^{-6}$

32 $(5.800 \times 10^7) - (5.8 \times 10^5)$

$\underline{5.742 \times 10^7}$

You may want to practice on the additional problems of Exercises 1 through 6 in the middle of the left-hand column of page 117 of your CHEM Study Laboratory Manual.